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IN RE APPLICATION OF: Makoto KASHIWAYA, et al.

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:

FOR: STIMULABLE PHOSPHOR SHEET

CERTIFICATION OF TRANSLATION

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P.O. Box 1450

Alexandria, VA 22313-1450

SIR:

I, Teiichiro OGAWA, residing at c/o ION Patent of HAYAKAWA-TONAKAI BLDG. 3F, 12-5, IWAMOTO-CHO 2-CHOME, CHIYODA-KU, TOKYO, 101-0032 JAPAN declare:

(1) that I know well both the Japanese and English languages;

(2) that I translated the attached document identified as corresponding to Japanese Application No. 2002-246628 filed in Japan on August 27, 2002 from Japanese to English;

(3) that the attached English translation is a true and correct translation of the document attached thereto to the best of my knowledge and belief; and

(4) that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements are made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both under 18 USC 1001, and that such false statements may jeopardize the validity of the application or any patent issuing thereon.

Date: December 6, 2006
Name: Teiichiro OGAWA

PATENT OFFICE
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This is to certify that the annexed is a true copy of the following application as filed with this Office.

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Application Number: Japanese Patent Application
No. 2002-246628

[ST.10/C]: [JP2002-246628]

Applicant: Fuji Photo Film Co., Ltd.

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Commissioner,
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Shinnichiro OTA

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Japanese Patent Application No. 2002-246628

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[TITLE OF THE INVENTION] Stimulable Phosphor Sheet

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[INVENTOR]
[DOMICILE OR RESIDENCE] c/o Fuji Photo Film Co., Ltd.,
2-12-1, Ogi-cho, Odawara-shi, Kanagawa
[NAME] Makoto KASHIWAYA

[INVENTOR]
[DOMICILE OR RESIDENCE] c/o Fuji Photo Film Co., Ltd.,
2-12-1, Ogi-cho, Odawara-shi, Kanagawa
[NAME] Junji NAKATA

[INVENTOR]
[DOMICILE OR RESIDENCE] c/o Fuji Photo Film Co., Ltd.,
798, Miyanodai, Kaisei-machi, Ashigara-kami-gun, Kanagawa
[NAME] Yasuo IWABUCHI

[APPLICANT FOR PATENT]
[IDENTIFICATION NO.] 000005201
[NAME] Fuji Photo Film Co., Ltd.

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[AGENT]

[IDENTIFICATION NO.] 100080159
[PATENT ATTORNEY]
[NAME] Mochitoshi WATANABE
[TELEPHONE NO.] 3864-4498

[AGENT APPOINTED]

[IDENTIFICATION NO.] 100090217
[PATENT ATTORNEY]
[NAME] Haruko MIWA
[TELEPHONE NO.] 3864-4498

[AGENT APPOINTED]

[IDENTIFICATION NO.] 100112645
[PATENT ATTORNEY]
[NAME] Hironobu FUKUSHIMA
[TELEPHONE NO.] 3864-4498

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[TYPE OF DOCUMENT] Specification 1 set
[TYPE OF DOCUMENT] Drawings 1 set
[TYPE OF DOCUMENT] Abstract 1 set
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[TYPE OF THE DOCUMENT] Specification

[TITLE OF THE INVENTION] STIMULABLE PHOSPHOR SHEET

[CLAIMS]

[Claim 1]

A stimutable phosphor sheet comprising a stimutable phosphor layer formed by a vacuum film forming technique, wherein

said stimutable phosphor layer contains a europium-activated cesium bromide based stimutable phosphor as a main ingredient; and

a maximum intensity of emission that is generated in a wavelength range of 490-510 nm when said stimutable phosphor layer is exposed to electron beams is lower than a maximum intensity of the emission generated in a wavelength range of 440-460 nm.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Technical Field of the Invention]

This invention belongs to the field of stimutable phosphor sheet technology, more particularly, relates to a stimutable phosphor sheet that has a stimutable phosphor layer deposited by vacuum film formation and which exhibits satisfactory photostimulated luminescence characteristics.

[Prior Art]

[0002]

There are known a class of phosphors which accumulate a portion of applied radiations (e.g. x-rays, α -rays, β -rays, γ -rays, electron beams and uv(ultraviolet) radiation) and which, upon stimulation by exciting light such as visible light, give off photostimulated luminescence in accordance with the accumulated energy. Such phosphors called stimutable phosphors (photostimulated phosphors) are employed in medical and various other applications.

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[0003]

An exemplary application is a radiation image information recording and reproducing system which employs a stimuable phosphor sheet having a layer formed of the stimuable phosphor. The layer is hereunder referred to as the phosphor layer and the stimuable phosphor sheet is hereunder referred to simply as a phosphor sheet or sometimes as a radiation image converting sheet. This radiation image information recording and reproducing system has already been commercialized by various companies including Fuji Photo Film Co., Ltd. which has marketed FCR (Fuji Computed Radiography).

In that system, radiation image information about the subject such as the human body is recorded on the phosphor sheet (more specifically, the phosphor layer) and thereafter the phosphor sheet is scanned two-dimensionally with exciting light such as laser light to produce stimulated emission which, in turn, is read photoelectrically to yield an image signal and an image reproduced on the basis of the image signal is output as the radiation image of the subject, typically to a display device such as CRT or on a recording material such as a photographic material.

[0004]

The phosphor sheet is typically produced by the steps of first preparing a paint having the particles of a stimuable phosphor dispersed in a solvent containing a binder, etc., applying the paint to a support in sheet form that is made of glass or resin, and drying the applied coating.

Phosphor sheets are also known that are made by forming a phosphor layer on a support through methods of physical vapor deposition (vapor-phase film formation) such as vacuum evaporation and sputtering (see, for example, JP

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2789194 B and JP 5-249299 A). The phosphor layer prepared by evaporation has excellent characteristics. First, it contains less impurities since it is formed under vacuum; in addition, it is substantially free of any substances other than the stimuable phosphor, as exemplified by the binder, so it has high uniformity in performance and still assures very high luminous efficiency.

[0005]

[Problems to be Solved by the Invention]

One of the most important characteristics required of the phosphor sheet may be the photostimulated luminescence characteristic. When the phosphor layer is illuminated with x-rays (the energy of x-rays is accumulated) and later stimulated by exciting light such as laser light, the phosphor layer gives off light. The photostimulated luminescence characteristic describes how much light is emitted relative to the exposure to x-rays.

Given the same levels for the exposure to x-rays and the intensity of the exciting light, the phosphor layer has a better photostimulated luminescence characteristic if it emits a greater amount of light upon stimulation. Hence, a phosphor sheet having the phosphor layer with a good photostimulated luminescence characteristic is a highly sensitive phosphor sheet that can produce adequate photostimulated luminescence even when it was illuminated with a small dose of x-rays.

[0006]

The process of taking an x-ray image using the phosphor sheet parallels imaging with an x-ray film in that the phosphor sheet is illuminated with x-rays through the subject, thereby taking an x-ray image on the phosphor sheet.

Therefore, the use of a highly sensitive phosphor

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sheet enables imaging at adequate intensity of x-rays even if it is illuminated with small quantities of x-rays. In other words, the exposure to x-rays is sufficiently lowered to reduce the burden on the subject.

[0007]

An object, therefore, of the present invention is to provide a stimuable phosphor sheet for use in the radiation image information recording and reproducing system and the like that has a stimuable phosphor layer exhibiting a satisfactory photostimulated luminescence characteristic.

[0008]

[Means to Solve the Problems]

In order to attain the object described above, the present invention provides a stimuable phosphor sheet comprising a stimuable phosphor layer formed by a vacuum film forming technique, wherein the stimuable phosphor layer contains a europium-activated cesium bromide based stimuable phosphor as a main ingredient; and a maximum intensity of emission that is generated in a wavelength range of 490-510 nm when the stimuable phosphor layer is exposed to electron beams is lower than a maximum intensity of the emission generated in a wavelength range of 440-460 nm.

[0009]

[Embodiment of the Invention]

On the pages that follow, the stimuable phosphor sheet of the invention is described in detail with reference to the preferred embodiment depicted in the accompanying drawing.

[0010]

Fig. 1 shows in conceptual form an example of the stimuable phosphor sheet according to the invention.

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The stimulable phosphor sheet generally indicated by 10 (which is hereunder referred to as phosphor sheet 10) consists basically of a substrate 12 having a stimulable phosphor layer 14 (hereunder a phosphor layer 14) formed on the surface by a vacuum film forming technique.

[0011]

The illustrated phosphor sheet 10 has only the phosphor layer 14 on a surface of the substrate 12. This is not the sole case of the invention and various other designs can be adopted as long as the phosphor layer 14 has the characteristics described below.

[0012]

For example, the phosphor layer 14 may be provided on top of a reflective film formed on a surface of the substrate 12 in order to improve the efficiency of emergence of stimulated light emission. Alternatively, a barrier film for preventing the oxidation of the reflective film may be provided between the reflective film and the phosphor layer 14. If desired, the phosphor layer 14 may be overlaid with a barrier film for preventing oxidation of the phosphor layer 14.

The reflective film may be exemplified by thin (0.01-5 μm) films made of Al (aluminum), Ag (silver), Al alloys, Ag alloys, etc. The barrier film may be exemplified by thin (0.01-5 μm) films made of Si (silicon) oxides, Ti (titanium) oxides, Si nitrides, Ce (cerium) oxides, Mg (magnesium) fluorides, etc.

These films may be formed by a variety of vacuum film forming techniques including sputtering and vacuum evaporation, from which a suitable one can be chosen depending upon the film to be formed.

[0013]

Further referring to the phosphor sheet 10 of the

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invention, the substrate 12 is not limited to any particular types and all kinds of substrates in sheet form that are employed in phosphor sheets may be adopted, as exemplified by those which are made of glass, ceramics, carbon, aluminum, PET (polyethylene terephthalate), PEN (polyethylene naphthalate), polyimide, etc.

[0014]

Speaking further of the phosphor sheet 10 of the invention, the phosphor layer 14 is a layer (film) that is formed by vacuum film forming techniques and which contains a stimuable phosphor as the main ingredient. It is a layer containing as the main ingredient a cesium bromide (CsBr) based stimuable phosphor using europium (Eu) as an activator, particularly, one that is represented by the general formula CsBr:Eu.

[0015]

In the phosphor sheet 10 of the invention, the ratio between the phosphor and the activator in the phosphor layer 14 is not limited to any particular value and an appropriate value may be determined in accordance with the composition of the stimuable phosphor. The preferred range is from 0.0005:1 to 0.01:1 in terms of molarity ratio between the activator and the phosphor.

The thickness of the phosphor layer 14 also is not limited to any particular value and the thickness that can assure an adequate photostimulated luminescence characteristic may be determined as appropriate for the composition of the phosphor layer 14. An advantageous range is from 50 to 1000 μm , with the range of 200-500 μm being particularly preferred.

[0016]

The phosphor sheet 10 of the invention is characterized in that when the phosphor layer 14 is exposed

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to electron beams, a maximum intensity of the emission that occurs in the range of 490-510 nm is lower than a maximum intensity of the emission in the range of 440-460 nm.

[0017]

Upon exposure to electron beams (e^-), a variety of phosphors give off light (cathode luminescence; hereinafter, referred to as CL) depending upon their composition.

While the mechanism behind stimulated CL from the phosphor layer 14 (europium-activated alkali metal halide based, stimutable phosphor) formed by the vacuum film forming technique has not been fully unraveled, the present inventors found as the result of their intensive studies that the photostimulated luminescence characteristic of the phosphor layer 14 can be improved by setting the CL's characteristic appropriately.

In the phosphor layer 14 in the phosphor sheet 10 of the invention, the CL's emission at 490-510 nm and the emission at 440-460 nm are closely correlated to the photostimulated luminescence characteristic and the phosphor layer 14 having a satisfactory photostimulated luminescence characteristic can be obtained by ensuring that a maximum intensity of the CL's emission in the range of 490-510 nm is lower than a maximum intensity of the emission in the range of 440-460 nm.

[0018]

The present invention has been accomplished on the basis of that finding and it realizes a phosphor sheet 10 having the phosphor layer 14 formed by the vacuum film forming technique, particularly a highly sensitive phosphor sheet 10 having excellent photostimulated luminescence characteristics, by means of adjusting a maximum intensity of the CL's emission from the phosphor layer 14 at 490-510 nm to be lower than a maximum intensity of emission at 440-

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460 nm, preferably to 70% or less, more preferably to 50% or less, of the maximum intensity of emission at 440-460 nm.

Therefore, the phosphor sheet 10 of the invention as applied to measuring equipment for medical purposes such as the aforementioned FCR has the advantage of reducing the dose of exposure to x-rays and thus realizing a substantial decrease in the burden on the subject.

[0019]

The method of CL measurement that can be used in the present invention is not limited in any particular way and commercial cathode luminescence spectroscopic devices may be employed.

Conditions for measurement including temperature and acceleration voltage are not limited in any particular way, either, and room temperature may be combined with appropriately set conditions that are suited to the cathode luminescence spectroscopic device used.

[0020]

The method of forming the phosphor layer 14 in the phosphor sheet 10 of the invention is not limited in any particular way and various vacuum forming techniques can be employed, including sputtering, CVD and vacuum evaporation.

The film forming material is not limited in any particular way, either, and phosphor containing materials as well as activator containing materials (including the activator alone) may be chosen appropriately in accordance with the composition of the phosphor layer.

[0021]

As already mentioned, the thickness of the phosphor layer 14 in the phosphor sheet 10 is preferably at least 50 μm , more preferably at least 200 μm , and it must be considerably thicker than those thin films which are formed by conventional vacuum film forming techniques. Hence, from

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productivity and other viewpoints, vacuum evaporation is preferably employed to form the phosphor layer 14.

As also mentioned above, the activator (e.g. europium) is contained in a much smaller amount than the phosphor. Therefore, in view of the composition and characteristics of the phosphor layer as exemplified by the precision in the addition of the activator and the state of its dispersion, binary or more complex vacuum evaporation is preferred, in which the activator containing material and the phosphor containing material are heated to evaporate separately. Binary or more complex vacuum evaporation in which the activator containing material is evaporated by resistance heating and the phosphor containing material is evaporated by heating with electron beams is particularly preferred because the two kinds of material can be evaporated in close enough positions so that a phosphor layer excellent in characteristics such as the sharpness of a reproduced image can be formed at a satisfactorily high rate.

[0022]

As already noted, a preferred phosphor is CsBr:Eu. In order to form the phosphor layer 14 of this composition, two film forming materials, cesium bromide (CsBr) and europium bromide (EuBr_x , x being typically 2-3), are subjected to vacuum evaporation, the cesium bromide being evaporated by heating with electron beams and the europium bromide by resistance heating, to perform vacuum evaporation so that the phosphor layer 14 comprising CsBr:Eu as the stimuable phosphor is formed on the substrate 12.

[0023]

The CL characteristics of the phosphor layer 14 to be formed can be controlled by adjusting the film forming

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conditions and performing post-treatments.

The CL characteristics of the phosphor layer to be formed may be controlled as appropriate for its composition and other relevant factors. For example, whichever film forming method is employed, the phosphor layer 14 having the desired CL characteristics is preferably formed as it is supplied with energy by heating the substrate, irradiating it with ions or otherwise treating it during film formation. It is also preferred to anneal (post-heat) the phosphor layer 14 after it was formed on the substrate.

The conditions for applying energy and annealing may be set as appropriate for the composition of the phosphor layer 14 to be formed, the film forming conditions, etc.

[0024]

While the stimuable phosphor sheet of the invention has been described above in detail, the invention is not limited to the foregoing embodiment and various modifications and improvements can of course be made without departing from the spirit and scope of the invention.

[0025]

[Examples]

The following example is provided for the purpose of further illustrating the present invention but should in no way to be taken as limiting.

<Example>

Using europium bromide as an activator's film forming material and cesium bromide as a phosphor's film forming material, binary vacuum evaporation was performed to prepare a phosphor sheet 10 as depicted in Fig. 1, with the CsBr:Eu phosphor layer 14 deposited on a surface of the glass substrate 12.

Europium bromide was heated with a resistance heater

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comprising a tantalum crucible and a 3-kW DC power supply. Cesium bromide was heated with electron beams from a 270° deflecting gun with a power of 10 kW.

[0026]

The substrate 12 was set on a substrate holder in a vacuum chamber as an apparatus for vacuum evaporation. After setting the respective film forming materials in specified positions, the vacuum chamber was closed and evacuated using a diffusion pump and a cryogenic coil.

At the point in time when the degree of vacuum had reached 6×10^{-4} Pa, vacuum evaporation was started by heating the cesium bromide at an EB acceleration voltage of -4 kV and an emission current of 250 mA (equivalent to a deposition rate of about 200 nm/sec) and the europium bromide by resistance heating at a current of 150 A (equivalent to a deposition rate of about 1 nm/sec). As a result, the phosphor layer 14 (CsBr:Eu) was formed in a thickness of about 500 μm .

During the formation of the phosphor layer 14, the substrate holder was kept heated to heat the substrate 12.

[0027]

By subsequent annealing in a nitrogen atmosphere for 2 hours, a phosphor sheet was completed.

[0028]

The above-described procedure was repeated under various conditions for heating the substrate during film formation (not heated or heated at 100 °C, 200 °C or 300 °C) and subsequent annealing (not annealed or annealed at 100 °C, 200 °C or 300 °C), thereby preparing a total of 16 phosphor sheets.

[0029]

Using a commercial CL (cathode luminescence) spectroscopic device having a 2-mm slit, the CL of each

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phosphor sheet was measured at an acceleration voltage of 10 kV and at room temperature. A maximum intensity of the emission at 490-510 nm was compared with a maximum intensity of the emission at 440-460 nm.

[0030]

The results of comparison between maximum intensities of CL emission at the two tested wavelengths for the respective phosphor sheets are shown in Table 1 below.

The symbols in Table 1 mean the following: ◎, a phosphor sheet showing a maximum intensity of CL emission at 490-510 nm which was not more than 50% of a maximum intensity of CL emission at 440-460 nm; ○, a phosphor sheet showing a maximum intensity of CL emission at 490-510 nm which was more than 50% but not more than 70% of a maximum intensity of CL emission at 440-460 nm; △, a phosphor sheet showing a maximum intensity of CL emission at 490-510 nm which was more than 70% but not more than 90% of a maximum intensity of CL emission at 440-460 nm; X, a phosphor sheet showing a maximum intensity of CL emission at 490-510 nm which was more than 90% of a maximum intensity of CL emission at 440-460 nm.

[0031]

[Table 1]

Table 1

*		Substrate's heating temperature			
		None	100 °C	200 °C	300 °C
Annealing	None	X	X	X	X
	100 °C	X	X	△	X
	200 °C	X	○	◎	○
	300 °C	X	X	△	X

[0032]

The phosphor sheets were then evaluated for their

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photostimulated luminescence characteristics. As it turned out, the phosphor sheet rated © in Table 1 had excellent photostimulated luminescence characteristics and the phosphor sheets rated ○ had satisfactory photostimulated luminescence characteristics. The photostimulated luminescence characteristics of the phosphor sheets rated △ in Table 1 were inferior to those of the phosphor sheets rated ○ but had no problem for practical purposes. However, the photostimulated luminescence characteristics of the phosphor sheets rated X in Table 1 were problematic for practical purposes.

The foregoing results clearly show the effectiveness of the present invention.

[0033]

[Effects of the Invention]

As described above in detail, according to the present invention, the stimuable phosphor sheet has its cathode luminescence in a specified condition and, hence, it is a highly sensitive stimuable phosphor sheet having satisfactory photostimulated luminescence characteristics. If the stimuable phosphor sheet of the invention is employed in a radiation image recording and reproducing system such as FCR, the dose of exposure to x-rays is sufficiently reduced to mitigate the burden on the subject.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[FIG. 1] Fig. 1 is a conceptual diagram of a stimuable phosphor sheet according to an embodiment of the invention.

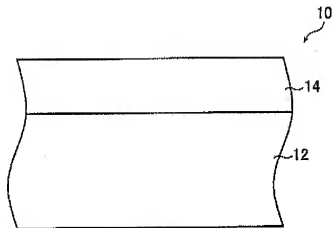
[Legend]

- 10 (stimuable) phosphor sheet
- 12 substrate
- 14 (stimuable) phosphor layer

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[TYPE OF THE DOCUMENT] Drawing

[FIG. 1]



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[TYPE OF THE DOCUMENT] Abstract

[ABSTRACT]

[Object] It is to provide a stimuable phosphor sheet that has a stimuable phosphor layer exhibiting a satisfactory photostimulated luminescence characteristic.

[Means for Solution] The above-described object is solved by a stimuable phosphor sheet comprising a stimuable phosphor layer formed by a vacuum film forming technique, wherein the stimuable phosphor layer contains a europium-activated cesium bromide based stimuable phosphor as a main ingredient; and a maximum intensity of emission that is generated in a wavelength range of 490-510 nm when the stimuable phosphor layer is exposed to electron beams is lower than a maximum intensity of the emission generated in a wavelength range of 440-460 nm.

[Selected Drawing] Fig. 1